# Monitoring Program Parameter Descriptions
## Clark County Public Works Water Resources

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**Document Directory**

## Background

This document summarizes the parameters and indicators used in monitoring activities by Clark County Public Works Water Resources. Monitoring activity is described in four parts including physical habitat assessment, hydrology, physical and chemical characteristics, and biological assessment. Each of the four parts provides a brief discussion of 1) the rationale for the selection of the parameter or indicator group, 2) the comparability to similar or standardized monitoring activities, and 3) a description of how the county implements the activity. This effort focuses on an objective of a Washington Department of Ecology water quality grant project intended to provide and coordinate monitoring resources and activities for the county and various local agencies, schools, and volunteers. The primary project objectives are to 1) standardize and document Water Resources' monitoring activities and 2) enhance communication of the activities with managers, agencies, and the public through coordination and training.

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## Physical Habitat Parameters and Assessment

*Rationale*

Land development in a watershed can impact stream habitat by altering stream channels and disturbing riparian areas. Impacts include sedimentation, passage barriers, destruction of riparian vegetation, bank instability, and removal of habitat including wood and pools (Booth et al., 2001). Stream habitat can be described as all the physical, chemical, and biological characteristics that influence or provide sustenance to organisms within the stream (Karr et al., 1986). Specifically, the term physical habitat refers to the structural characteristics of stream habitat, often excluding chemical and biological elements. Measures of physical habitat features that influence stream ecology include stream shape and size, gradient, substrate, habitat type, riparian vegetation, and human disturbance (Kaufmann, 1993).

Effective policy and management decisions require stream habitat information that is accurate, precise, and relevant (Kaufmann, 1999). The information also needs to be easily interpreted. But agencies, tribes, and non-governmental and private organizations in the Pacific Northwest often use a wide variety of stream habitat data collection and assessment techniques. Variations in approaches stem from organizations' needs to provide data relevant to specific mandates and research objectives. A recent project intended to establish a consistent format for the collection of salmonid habitat data found that efforts are largely uncoordinated or unlinked, have different objectives, use different indicators, and lack support for sharing the data (Johnson, et al., 2001). Furthermore, programs that collect data outside of salmonid recovery efforts, such as NPDES monitoring programs, need robust, flexible data collection methodologies to describe a variety of receiving water conditions.

*Comparability*

The field approach described by Kaufmann and Robison, 1994 and 1998, and Kaufmann et al., 1999, has been used as the standard method of stream habitat data collection by the EPA's Environmental Monitoring and Assessment Program (EMAP), by various Regional EMAPs in states and EPA regions, by several National Parks, and by private industries. Protocols that were developed for use in urban and sub-urban environs, such as University of Washington's Center for Urban Water Resources Management physical habitat assessment protocols for Puget Sound lowland streams, follow a very similar design. The EMAP protocol is standardized, comparable to other habitat data collection methods, and has been applied in the Mid-Atlantic and central US, Colorado, California, and the Pacific Northwest states. EMAP methods strive to make the data collection process objective and repeatable by using easily learned measures of physical habitat in place of estimation techniques wherever possible.

The EMAP protocols are comparable to another commonly used habitat method, the EPA's Rapid Bioassessment Protocol (RBP) Rapid Habitat Assessment. An additional level of the RBP habitat assessment includes steps to measure many of the quantitative variables measured in the EMAP procedure. The RBP assessment provides a "score" of habitat condition whereas the EMAP protocols focus on direct measurement of habitat elements. Data generated by a quantitative approach must be compared with data from sites with a *desired condition* in order to provide information on habitat quality. Kaufmann et al., 1999, found that the two methodologies yielded similar results, however, that the data provided by the qualitative RBP assessment were less precise.

*Implementation*

Water Resources' monitoring program utilizes both the EPA's quantitative and qualitative physical habitat methods. Components from the EPA's EMAP field protocols are used for projects requiring accurate, repeatable measurements of physical habitat. An example includes a current project to document long-term changes in the chemical, physical, and biological characteristics of ten stream sites in the county. The habitat surveys in the EPA's Rapid Bioassessment Protocol are used for rapid assessment of the condition of stream habitat. Macroinvertebrate sampling, for example, requires information about habitat condition that can be provided by this qualitative approach. In combination, these standardized, documented, and widely used protocols provide the information the county needs for its programs.

Listed below are the components of the EMAP physical habitat assessment and the field measurements associated with each. Water Resources follows a modified EMAP protocol, documented in its **standard procedures** (Wierenga et.al, 2002).

Quantitative physical habitat field measurements:

- **Thalweg profile**
  *100-150 measurements along reach:*
  - Maximum depth
  - Habitat features
  - Pool-forming features
  - Backwaters, side channels
  - Soft, small sediment deposits

  *10 measurements(midway between 11 channel cross-section transects):*
  - Wetted width
  - Substrate size class*
- **Woody debris tally**
  *Between 11 channel cross-sections*:
  - LWD number, length, and dia.
- **Channel and riparian characterization**
  *At 11 cross-section transects*:
  - Channel cross-section
  - Wetted width
  - Bank height
  - Bank undercut
  - Bank angle
  - Slope and compass bearing
  - Riparian canopy density
  - Substrate size class*
  - Embeddedness
  - Riparian areal cover class and type
  - Fish concealment areal cover
  - Aquatic macrophytes areal cover
  - Filamentous algae areal cover
- **Channel constraint, debris torrents**
  *For entire reach:*
  - Identify channel constraint features
  - Percentage of constrained channel
  - Ratio of bankfull/valley width
  - Flood evidence and debris torrents
- **Discharge**
  *At one representative cross-section*:
  - Water depth and velocity at 15-20 intervals across the cross-section.

*Substrate size class is estimated for a total of 105 particles taken at 5 equally-spaced points along each of 21 cross-sections.

The measurements above allow the calculation of approximately 150 individual habitat metrics. EMAP recommends a list of 49 most frequently used metrics, with a subset of 18 metrics generally considered to be the most useful. Water Resources calculates these 18 recommended metrics (listed below), as well as others from the EMAP list of 49 frequently-used metrics.

Example EMAP Metric Categories:

- **Channel morphology**
- **Channel cross-section and bank morphology**
- **Channel sinuosity and slope**
- **Residual pools**
- **Substrate size and composition**
- **Bed substrate stability**
- **Fish cover**
- **Large woody debris**
- **Riparian vegetation cover and structure**
- **Human disturbances**

Listed below are parameters evaluated in the EPA's Rapid Bioassessment Protocol. Water Resources follows a standard procedure for performing the RBP habitat assessment and recording the associated reach characteristics and features.

Qualitative habitat assessment parameters:

- **Epifaunal substrate/cover** – estimates the relative quantity and variety of natural structures in the stream available as habitat for stream-life.
- **Embeddedness or pool substrate characteristics** – evaluates the bottom condition of riffle/run and pool/glide streams separately.
- **Velocity/depth or pool variability** – evaluates the diversity of waterway surroundings as habitat in riffle/run and pool/glide streams separately.
- **Sediment deposition** – estimates the amount of sediment accumulated in pools.
- **Channel flow status** – estimates the degree to which the stream channel is filled with water.
- **Channel alteration** – estimates the large-scale changes in the shape of the stream channel.
- **Frequency of riffles or channel sinuosity** – estimates the diversity of habitat unit type in riffle/run and pool/glide streams separately.
- **Bank stability** – estimates whether the stream banks are eroded or have the potential for erosion.
- **Bank vegetative protection** – estimates the amount of vegetative protection afforded to the stream bank and near-stream portion of the riparian zone.
- **Riparian vegetation zone width** – estimates the width of natural vegetation from the edge of the stream bank out through the riparian zone.

## Hydrologic Parameters

*Rationale*
Stream degradation in urbanizing areas results from altered watershed hydrology, specifically by modifying channels and changing the path of water to the streams. Impacts include channel erosion, altered channel morphology, washout of biota, unseasonable drying of stream and streambed, disconnection and loss of floodplains, and increased occurrence and magnitude of flooding (Booth et al., 2001). Flow also represents the pollutant loading mechanism that can degrade habitat and lower biological integrity (Burton and Pitt, 2002).

Urban development and land clearing can influence the temporal patterns of stream flow, which is a critical element of stream ecosystems (Booth et al., 2001). Physical habitat and biological condition are closely tied to water availability during critical periods of the season, low and high flow. Increased runoff with declining sediment yield in a watershed can result in channel incision and widening, coupled with excess deposition of the sediment from eroded channels downstream of impacted areas (Bledsoe and Watson, 2001). Because stream hydrology is related to other physical stream components, some in-stream impacts, such as widening and down cutting, are assessed using physical habitat monitoring techniques described in the previous section.

Typical field measures of hydrology include instantaneous and continuous discharge measurement, and occasionally channel dimensions and gradient. A description of the hydrology of streams is accomplished through field measurements and simulation models.

*Comparability*
Measuring water velocity using a current meter and determining cross sectional area with multiple width and depth measurements is the typical approach to instantaneous discharge measurement. The US Geological Survey has developed guidelines for obtaining accurate discharge data (Rantz et al., 1992). Regional and state governments, contractors, and private industry follow this standardized approach in stream discharge data collection. In addition, industry standards for equipment used to continuously measure water level and velocity ensure comparability.

*Implementation*
Water Resources measures instantaneous velocity for chemical and physical constituent sampling, as well as during macroinvertebrate and habitat surveys. A standard procedure for collecting water velocity and depth data (Wierenga et.al, 2002) was developed following USGS guidelines (Rantz et al., 1992). Many of the physical attributes used to describe hydrologic conditions in streams are measured following the physical habitat assessment protocols. The physical habitat metrics may include bed/substrate stability, gradient, sinuosity, and channel volume.

Water Resources’ stream gauging and water quality monitoring sites use digital water level instrumentation to record water level. Instantaneous stage is also measured from staff gauges placed at various monitoring stations. Rating curves are developed at long-term county monitoring stations following USGS guidelines (Rantz et al., 1992).

## Chemical and Physical Parameters and Miscellaneous Field Measurements

*Rationale*

Some human activity in watersheds can impact the water quality of streams from both point and non-point sources of contaminants. Impacts include increased water temperature, turbidity, oxygen sags, nutrient enrichment, and chemical contaminants (Booth et al., 2001). Collecting water samples for physical and chemical analyses is an integral part of water quality surveys. Many programs operating under federal and state mandates are required to investigate the condition of water bodies considering physical and chemical standards or criteria to safeguard designated beneficial uses such as supply, swimming, and fishing. Water sample data is used to determine baseline conditions, identify problems that pose risks to humans or wildlife, assess impacts of development or rehabilitation, determine the compliance of regulated activities, and to inform and educate the public.

Water sampling approaches are project specific and require a great amount of attention to provide useful information. Furthermore, the variety of techniques available for organizing, summarizing, analyzing, and communicating water quality data can be overwhelming. Water sampling data is also highly variable; consequently a large amount of spatially and temporally dense data is often required to meet project objectives. Frequently, projects fail to meet expectations due to a design that relied on a few, scattered data points. Many agencies rely less upon physical and chemical data due to the difficulty of interpreting and communicating the data. Furthermore, generating useful information requires a great deal of time and money, resources that are not available to many organizations tasked with environmental monitoring.

Nonetheless, water sampling provides insight that cannot be extracted from other types of monitoring. NPDES municipal stormwater permits often have monitoring objectives that are only attainable through water sampling, such as identification of pollution sources and determination of pollutant concentrations and loads. Physical and chemical water data are also used to characterize receiving waters and determine designated use attainment. Researchers analyze data with statistical methods and models that provide the information needed for management decisions. Regionally applicable water quality indices are used to aggregate data and communicate results to stakeholders and the public.

*Comparability*

In general, monitoring programs and laboratories follow standard methods approved by regulators or industries for water sampling and analytical methods. Documentation of sampling and analytical methodology allows comparison with other data. Water quality data are applied to common data analysis tools, including calculating water quality indices, comparing data to standards and criteria, and using standard statistical techniques.

*Implementation*

Table 1 lists the physical and chemical parameters used by Water Resources; data uses are shown in the table as well. Some parameters are used for more than one type of project. In general, physical and chemical parameters are grouped for 1) long-term monitoring of receiving waters, 2) screening for illicit stormwater connections, 3) particular monitoring projects such as bacterial screening, and 4) lake sampling. Samples are collected utilizing grab techniques or by automated sampling equipment placed at monitoring stations. All samples are preserved, stored, and analyzed according to methods developed by the County’s contracted commercial laboratory.

Long-term trend data is used to calculate an index of water quality developed by the Oregon Department of Environmental Quality (ODEQ) (Cude, 2001). The index is a single number that expresses water quality for general recreational use by integrating measurements of eight water quality parameters. Indices in general are helpful for aggregating and communicating regularly measured variables, as well as for determining trends in data. However, indices are not capable of determining the quality of water for all uses, specifically where some uses conflict with others. In addition, indices cannot evaluate all hazards for human or ecosystem health. The Oregon water quality index was selected for the following reasons:

1. The methodology is peer reviewed and applied by Oregon state for 305b reporting.
2. Parameters for the index are well suited to Clark County's long-term monitoring program.
3. Physiographically the county is considered part of Oregon's Willamette Valley ecoregion , where the index is corrected and has been applied for nearly two decades.
4. Washington Department of Ecology's water quality index is still in development and although it addresses physiographic influence on nutrient and sediment data, Clark County's physiography is not represented in the calculations.

Table 1. Chemical and physical parameters determined during sampling and field measurements.

<table>
<tr><th>Parameter</th><th colspan="4">Data Use</th></tr>
<tr><td>Odor</td><td rowspan="17">Illicit stormwater connection screening</td><td rowspan="10"></td><td rowspan="13"></td><td rowspan="11"></td></tr>
<tr><td>Color</td></tr>
<tr><td>Floatable matter</td></tr>
<tr><td>Deposits/stains</td></tr>
<tr><td>Zinc/copper metals</td></tr>
<tr><td>Hardness</td></tr>
<tr><td>Potassium</td></tr>
<tr><td>Surfactants/fluorescence</td></tr>
<tr><td>Chlorine</td></tr>
<tr><td>Toxicity</td></tr>
<tr><td>Turbidity</td><td rowspan="4">Miscellaneous parameters</td></tr>
<tr><td>Total suspended solids</td><td rowspan="2">Lake parameters</td></tr>
<tr><td>Specific Conductance</td></tr>
<tr><td>E.coli/fecal coliform</td><td rowspan="9">Water quality index</td><td></td></tr>
<tr><td>Water temperature</td><td rowspan="12"></td><td rowspan="4">Lake parameters</td></tr>
<tr><td>PH</td></tr>
<tr><td>Ammonia-N</td></tr>
<tr><td>Dissolved oxygen</td><td rowspan="9"></td></tr>
<tr><td>BOD</td><td></td></tr>
<tr><td>Nitrate-N</td><td>Lake</td></tr>
<tr><td>Total solids</td><td></td></tr>
<tr><td>Total phosphorus</td><td rowspan="5">Lake parameters</td></tr>
<tr><td>Secchi disk</td><td rowspan="4"></td></tr>
<tr><td>Chlorophyll-a</td></tr>
<tr><td>Total Kjeldahl Nitrogen</td></tr>
<tr><td>Biological samples</td></tr>
</table>

Long-term data is also compared to regulatory standards and criteria in the Washington Administrative Codes. State standards are intended to protect the designated uses of waterways.

Monitoring for the screening of illicit stormwater connections to county stormwater facilities is a NPDES municipal stormwater permit requirement. A sampling approach and parameter list developed by the EPA was used as guidance for developing a field procedure used annually for the program (Pitt et al., 1993). Laboratory data is evaluated according to compliance with Washington State regulatory standards.

Lake sampling activity typically consists of water sampling for nutrients or biological parameters such as chlorophyll a or algal assemblage, and field measurements of temperature, pH, dissolved oxygen, conductance, and water clarity.

## Biological Parameters and Assessment: Macroinvertebrate Community Measurements

*Rationale*

Benthic macroinvertebrates are visible insects, crustaceans and other organisms that live on or in the streambed. These communities of insects live in streams for all or part of their life cycles and rely on the stream environment to provide protection and food. Researchers have found that this biological community responds to the deterioration of stream conditions with measurable changes in species composition and relative abundance (Karr, 1998). Thus, an assessment of the macroinvertebrate community 1) provides information about the overall health of a waterway and 2) identifies potential sources of chemical or physical impairment.

In the monitoring approach, large numbers of individuals are collected from a site and the diversity and abundance of different types of creatures in the sample is determined. Ten measurements, or metrics, that describe the community of macroinvertebrates are then calculated from the raw data. The Benthic-invertebrate Index of Biological Integrity (B-IBI) is a regionally developed index, calculated from the set of metric data and used as an overall indicator of stream health (Karr, 1998; Karr and Chu, 1999). The index is used to measure changes in biological communities from activities impacting the stream or watershed, both degrading and rehabilitating actions. Researchers have found the B-IBI to be sensitive to minor impacts from human disturbance within streams in Washington State (Fore, 1999; Merritt et al., 1999).

*Comparability*

The B-IBI has been used to estimate the effects of a wide variety of land uses on streams in the Puget Sound area including urban and suburban development, forestry, and agriculture. Currently, Seattle Metro, Seattle Public Utilities, Cities of Bellevue, Issaquah, and Kent; and Kitsap, Pierce, Snohomish, and Thurston Counties, use a common protocol and the B-IBI for management and permitting purposes (Johnson et al., 2001). Volunteer groups, including Salmonweb and the Clallam County Streamkeepers in Washington State, also collect macroinvertebrate data utilizing the protocol.

The applicability of the B-IBI to the broad spectrum of Northwest streams is a topic of discussion among agencies and private groups involved in the Northwest Biological Assessment Workgroup (http://www.epa.gov/r10earth/offices/oea/aqbioass.html). A Washington Department of Ecology study in the Pacific Coast and Yakima Basin ecoregions in Washington State found the B-IBI to be a good indicator of stream health in a variety of environs (Merritt et al., 1999).

*Implementation*

An important element of Clark County's stormwater permit program includes monitoring and assessment of receiving waters. Biological monitoring is a fundamental component of this effort, from the standpoint of tracking trends that are either improving or degrading in the county's waterways. Water Resources' activities follow a field protocol developed by the Washington State Department of Ecology (Ecology) for field sampling of benthic macroinvertebrates. At a selected stream reach, samples are collected from a two square-foot area in four riffle habitat units with a D-frame kicknet (500-micrometer net mesh size). A composite is made of the four replicates representing each habitat unit, such as riffles and pools if both are sampled. Samples are processed at a professional laboratory where invertebrates are counted and identified to the species level, or the lowest practicable level.

The B-IBI is calculated from the raw data by the laboratory. The ten metrics for the B-IBI calculation are shown below:

1) Total Taxa Richness
2) Ephemeroptera Taxa Richness
3) Plecoptera Taxa Richness
4) Trichoptera Taxa Richness
5) Number of Long-Lived Taxa
6) Number of Intolerant Taxa
7) Percent Tolerant Individuals
8) Number of Clinger Taxa
9) Percent Predator Individuals
10) Percent Dominance

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